CBS LABORATORIES

Contract No. 950848

FINAL REPORT

1-1/2 INCH RUGGED IMAGE DISSECTOR TUBE

Period Covered: February 25 1964 to September 18, 1964

Project No.: 5001

Date: October 12, 1964

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1. INTRODUCTION

The purpose of this program was to redesign the CL 1209A Image Dissector Tube to provide a tube with improved ruggedness. The basic design of the CL 1209 Image Dissector, which was developed under JPL Contract #959954, was retained.

Specific areas in which improvements were made included: -

(i) The addition of "snubbers" to the electron multiplier assembly. These snubbers were designed to keep the movement of the electron multiplier assembly to an absolute minimum during exposure to severe environmental conditions.

(ii) All cylindrically mounted and welded components were provided with specially formed tabs in order to eliminate stress and improve the weld quality between the components.

(iii) Tooling was designed and made for the precision manufacture of the image section components. Besides improving the ruggedness in this area, the parts were intended to result in a greater uniformity of electron optical performance.

(iv) The establishment of critical assembly techniques in which the latest technology in welding techniques was utilized.

These and other structural modifications discussed, in addition to improvements in processing techniques, resulted in the manufacture of a rugged image dissector tube, with improved electronic characteristics, which can withstand environmental stresses greatly in excess of the Mariner "C" Mars flight qualification test.

Eleven tubes conforming to the electronic specifications were delivered.

2. IMAGE DISSECTOR DESIGN AND OPERATION

The electron optical design and the basic mechanical design of the CL 1209A is described fully in the Interim Final Engineering Report of JPL Contract No. 950054. In this program effort was directed at making mechanically superior tubes with improved electronic performance characteristics.

The image dissector tube is used as the sensor in a guidance system which is intended to determine the relative position of a space vehicle in relation to a source of radiant flux; e.g., a star.

The operation of an image dissector can be described briefly as follows:

An optical image (in this application, a star image) which is formed at the entrance window of the image dissector, is converted to an electronic image at the photoemissive cathode deposited on the inside surface of the window, (See Figure 1). The electronic image consists of photoelectrons emitted from the cathode surface with varying densities dependent upon the magnitude of incident illumination; i.e., the greatest number of photoelectrons are emitted from that portion of the image corresponding to the maximum illumination area of the optical input and no photoelectrons are emitted from areas corresponding to the black portions of the aerial image. The photoelectrons generated at the photocathode are accelerated and electron optically focused on the plane of an electron aperture so that an image of the current distribution at the photocathode is formed in the plane of the aperture plate. If the imaging section were to be coupled to a phosphor screen instead of an aperture plate, an inverted optical image would be visible in the focal plane. However, with a solid plate, having a small aperture at its center, only that portion of the electronic image which is formed directly over the aperture is permitted to pass through the aperture. By incorporating a deflection system between the photocathode and aperture electrodes, the electronic image may be swept across the aperture allowing each segment of the image, equal in size to the aperture, to pass sequentially through the aperture.

Knowledge of the deflection program provides sufficient information to associate each segment of the electronic image with the corresponding segment of the optical image. By the introduction of an electron multiplier behind the image section, the electronic signal passing through the aperture is amplified to a readily measurable level.

3. MECHANICAL CONSIDERATIONS AND DESIGN CHANGES

3.1 General

The prime object of this program was to improve the ruggedness of the CL 1209 which was developed under JPL Contract No. 950054. At the same time consideration was to be given to improvements in the overall electronic performance of the tube. In the electron multiplier section of the tube, structural failures in the form of broken support wires had occurred in the region of the stem. The major cause of this was the stress imposed in that area by the excursions of the stem end of the electron multiplier during severe environmental tests. The purpose of the redesign in this area was to restrict this movement to a minimum.

A structural failure also occurred in the image section of one tube being environmentally tested. The failure was located where two cylindrically shaped parts, one a component of the tube envelope and the other the focus electrode, were welded together one inside the other. In the tube assembly it is necessary to spot weld these parts together without puncturing the thin envelope component. To do this, close tolerance parts are essential if a good electrical contact for welding is to be made. The difficulty of providing this contact and therefore reproducible welds with spun and machined parts had previously been observed, therefore the second major design task of this program was to provide parts with which optimized welds and stress free assemblies could be made. This was accomplished by the design and fabrication of tools to make the parts by press work. In addition to improving the mechanical strength of the tube assemblies the pressed parts allow closer geometrical tolerances to be held in the electrode configuration. Because of this the electron optical performance of the tubes is more consistent. During the redesign of the tube, particular attention was given to the method of assembly and the welding technique to be used for each weld. Complete engineering and specifications of the parameters of each weld ensure the utmost in reliability, and the reproducibility of quality welds.

3.2 The Electron Multiplier Construction

During the environmental testing of previously manufactured tubes it was observed that the anode end of the electron multiplier structure was moving with respect to the tube axis when the direction of vibration was normal to the tube axis. Movement was also observed in the electron multiplier connections to the stem leads and in the stem leads themselves. An earlier measure in which the diameter of the stem leads was increased and the assembly welding schedules revised had eliminated previous points of failure, however it was felt that if the movement could be eliminated, the structure would have a greater degree of reliability. To eliminate the movements a stiff support has been provided near the anode end of the electron multiplier assembly by means of two snubbers which are held between the electron multiplier side supports (ceramics) and the thick glass envelope. The snubbers are clearly shown in Figures 2 and 3. The glass envelope, side supports and the snubbers hence form a mutually tight fit, which by selection of materials of required physical properties and the use of precision bore glassware provide a solid support which is compatable with the thermal processes to which the tube is exposed during manufacture. This arrangement eliminates the movement of the electron multiplier assembly and therefore the resultant stress on the stem welds, stem pins and support cross wires. The stiff snubbers, although fitting tightly, are capable of discrete roll about their mounting pins in the direction of the tube axis. This automatically increases the snubber to glass grip when the multiplier tends to move in the axial direction.

The introduction of the snubber required the relocation of the cesium generator and its mounting so that the multiplier assembly would mate perfectly with the snubber. The end of the electron multiplier close to the image section is attached to the aperture cup which is in turn welded to a metal component of the envelope. Since some flexing was apparent, in tubes, before the use of the snubber previously described, the possibility of adding additional support was investigated. The lack of space and the assembly procedures, prevented any changes in the mounting of the multiplier assembly to Dynode #1 and the aperture cup. However some strengthening was achieved by revision of assembly techniques. This measure and the total removal of the flexing by the snubbers naturally resulted in a greatly strengthened assembly.

The close mechanical fit between the snubbers and the tube envelope assures an even distribution of the snubber stress over a wide surface of the glass.

Particular attention was given to the development of stress free assembly techniques. The multiplier stem leads were aligned to provide a direct contact between the stem and multiplier electrode leads before welding. As a result the deformation of the wires during the actual welding operation and the resultant introduction of stress was minimized.

3.3 The Image Section

The anode and the focus electrode of the image section were redesigned to eliminate the stresses introduced in joining the cylindrical portions of the electrodes to similarly shaped components of the glass envelope. Press tools for the fabrication of these were made. The welding tabs, shown in Figure 4 on the two parts of the focus electrode and the anode cone permit the stress free assembly of these parts within the tube. The tabs also ensure the maintenance of consistent weld strength since they give readily under the pressure of the spot welding electrodes. The fabrication of the focus electrode in two parts reduces the intricacy involved in installing the cathode material sources within the electrode and thus greater reliability can be assured. The forming of these parts by press tools and the between stage annealing, limits the build up of internal stresses during the part manufacture. This reduces the possibility of stress relief, resultant part deformation and breakage of coupled parts during the thermal cycling in the processing of the assembled tubes.

3.4 The Deflectron

The reliability of the deflectron has been increased by providing an additional electrical link on the outer surface of the cone between the two pins of each electrode. In addition the electrical connection between the deflectron and the envelope lead throughs is now made to the deflection pins near the apex of the cone where the accessibility allows better weld control. An improved method of establishing electrical contact between the deflection patterns and the pin connection was developed. The method eliminates the possibility of spontaneous electrolysis between the Kovar pin and silver deflection pattern. Connections made this way have uniformly low resistance and are stable on repeated exposure to elevated temperatures.

Figure 5 is a photograph of a deflectron electrostatic deflection yoke and the anode cone/deflection system assembly jig. The jig is designed to accurately position the deflectron within the anode cone during the assembly procedure.

4. TUBE MANUFACTURE

4.1 Specifications

With the object of obtaining product of reproducible quality, a series of processing specifications have been issued. Each processing specification was finalized with a Process Evaluation Test. In particular a study has been made of cleaning controls and surface conditioning procedures. The processes are controlled by tightly specified limits in the purity of reagents, time, PH levels of solutions and temperature. All together more than 40 specifications and specification combinations were introduced, and optimized.

4.2 Post Exhaust Processing

An aging rack has been developed which permits close control of gas pressure inside of the tube during aging processes. The pressure inside the dissector is held at 10^{-9} Torr or less during the entire aging process. The changes in pressure are indicated by changes in current in the ion pump which is not removed until the end of the aging process. Spot-knocking equipment was built to provide a controlled discharge across leakage paths between the neighboring elements. This process is performed at well defined and controlled pressures inside the tube while the dissector is continuously pumped. This operation substantially reduced the ohmic leakage between the separate electrodes of the electron multiplier assembly.

4.3 Tooling

Emphasis was placed upon improved tooling to ensure alignment of components and to eliminate the possibility of imposing strains between components during assembly. The latter precaution was particularly necessary in the deflection cone assembly, where the glass cone is rigidly fitted into the metallic anode cone. Further to improve reliability of welds fixtures were made to permit pre-alignment of the components prior to actual welding.

5. TECHNICAL PROBLEMS AND THEIR EVALUATION

5.1 Tube Envelope

Seven tubes failed prior to or during pumping because of vacuum leak in the glass-to-metal seal. All of these were made from parts processed at one particular time. To prevent reoccurrence of this problem, additional specifications and qualification tests were introduced. In these each batch has to satisfy low temperature (-180°C) and elevated temperature (400°C) seal tests prior to entering the assembly flow.

5.2 Dynode Uniformity

A definite link was established between the dynode uniformity and the silver-magnesium surface preparation. The introduction of new cleaning procedures and surface buffing techniques resulted in an increase of average dynode uniformity to above 80%. A histogram showing the effect of this processing is shown in Figure 6. It has also been established that dynode uniformity of dynode cleaned by new technique shows no deterioration during burn-in processes. (Maximum 4%).

An additional insight into the mechanism of dynode uniformity has been obtained by applying strong electrostatic fields to Dynode #1. It was assumed that the difference in force acting on different molecules when subjected to same electrostatic field might optimize the composition of the surface boundary of the silver-magnesium liner. Experiments were conducted using different electrostatic fields for different periods of time. It was observed that the dynode uniformity increased with the time and strength of the electrostatic field. (See Figure 7).

This method has been used to correct dynode uniformity prior to burn-in on some of the tubes. The improvement in dynode uniformity obtained by the use of this process was unchanged after the hundred hour burn-in test.

5.3 Photocathode Uniformity

An investigation into the causes of poor cathode uniformity revealed that degradation of the center area of the photocathode was occurring in some tubes, during the aging process. In this process the tube is operated at continually higher levels while still being exhausted by an ion pump to ensure that the gas released from the active surfaces of the tube during its initial operation is removed. Close monitoring of the process revealed that the gas pressure sometimes exceeded the maximum desirable level and that it was necessary in some tubes to prolong the treatment. Because of the extended processing and the necessity of simultaneous aging of up to four tubes, an aging rack was built. This permitted the individual control and pressure monitoring of each tube. In the subsequent aging of tubes the radiant input flux and the applied voltage to each tube was increased gradually to avoid exceeding a pressure of 19^{-9} Torr within the tubes. The adoption of this procedure almost totally eliminated the poor cathode uniformity problem.

5.4 Dark Current

The dark current in an image dissector is the current measured at the anode when the tube is energized and operated withou a radiant flux input. This current, which is composed of uni-directional pulses and direct electrical leakage, is the current measured in the anode circuit by a D.C. moving coil instrument.

The current may be divided into two general classifications:

(i) Fundamental currents i.e., the multiplied thermal emission from the photocathode and the secondary emissive surfaces. This cannot be avoided, however, it is negligible compared with the leakage currents.

(ii) Spurious dark currents. These are leakage currents and currents caused by spurious effects such as ion feedback. By careful design and processing these can be minimized. However, they still form the major part of anode dark currents.

Observation of the noise spectrum, with a multichannel analyser, when various voltages were applied across the electron multiplier section of a tube, indicated that:

(i) The number of counts for each energy level and for each period of time was constant for applied voltages of up to 105 volts per stage (See Figure 8).

(ii) At higher voltage levels the initially high count rate decreased during the testing period.

(iii) Once a tube had been tested at a higher voltage level, the initial count rate, after further shelf life, was lower than in the first test. Although somewhat erratic, it was established that the count rates of the tubes tested was directly related to the dark current measurement. The above tests were performed at a temperature of 40°C.

The findings from the above experiments indicated that application of higher potentials between electrodes decreases dark current, without detrimental effect on other electrical characteristics. Further pursuit of this resulted in the introduction of the spot-knocking process. The spot-knocking process was accomplished by charging a capacitor to progressively higher potentials and then connecting it between neighboring electrodes of the image dissector electron multiplier. During the process the rate of increase of voltage was adjusted to insure that the gas generated by the discharges did not cause the tube pressure to exceed 10^{-7} Torr as indicated by the ion pump current meter. This method permitted the application of up to 4000 volts between any two neighboring electrodes. Tubes spot-knocked under these conditions were observed to have a very low count rate as recorded on a multichannel analyzer.

At the end of the project experiments were finalized to locate the centers of contamination responsible to a large extent for dark current. A critical area in the stem tubulation was found from which impurities were fed back into the tube. Changes in processing of the tube on the pump reduced dark current by more than 50%. However, an insufficient number of tubes were processed to allow any definite conclusions to be drawn.

6. ANALYSIS OF MANUFACTURE AND TESTING

Thirty-one (31) tubes were exhausted in this program and of these twenty (20) were finally tested, according to JPL Specification 31163A.

Eleven (11) tubes meeting the requirements of the Specification were encapsulated and delivered under the program.

Of the nine (9) rejects seven (7) were found to have defective glass to metal seals, one (1) had poor dynode uniformity and one (1) failed in processing because of a perforated cesium generator.

On completion of the contract the remaining eight (8) tubes were at varying stages of post exhaust treatment and evaluation.

The test results of the eleven (11) tubes delivered is tabled below.

CL 1209 TEST RESULTS

Tube Identification Number	P. Cath. Sens. µA/L	P. Cathod. Uniformity %	Gain $\times 10^6$	Dark Current µA	Dynode Uniformity %	Deflection Plate Misalignment
1057	37	78	58	.038	88	0°51'
1058	40	94	1.7	.031	89	1°43'
1061	45	93	1.75	.025	86	2°17'
1065	32	95	4.0	.020	86	5°43'
1066	40	93	1.95	.020	86	0°34'
1067	35	94	75.0	.020	86	1°9'
1068	32	90	52.0	.024	86	3°26'
1072	43	86	61.0	.028	70	1°9'
1073	34	97	7.8	.04	86	0°34'
1075	31	87	7.0	.022	80	3°26'
1076	37	87	28.4	.0046	76	2°51'

7. ENCAPSULATION

Eleven tubes were encapsulated in a composite assembly which included alignment rings, magnetic shields and a voltage divider network for the electron multiplier. Figure 9 is a photograph of an encapsulated tube.

In the encapsulation procedure, the tube is aligned within the rings so that the outer surface of the faceplate is perpendicular, within five seconds of an arc, to the assembly axis as determined by the rings.

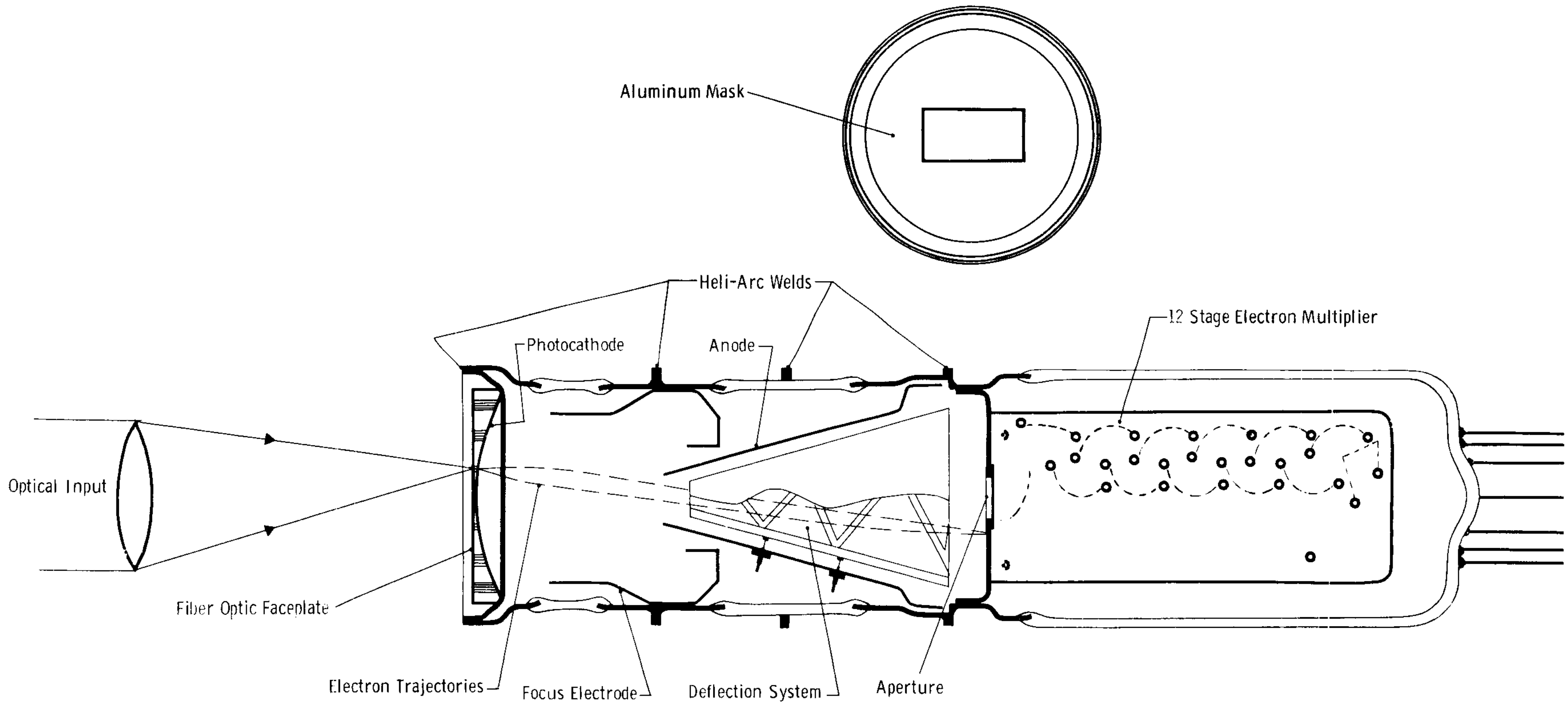
8. CONCLUSIONS

An extremely rugged image dissector tube capable of withstanding mechanical shock and vibration greatly in excess of the Mariner C, spaceflight, Qualification Acceptance levels, has been developed.

The technical progress achieved in the control of dynode uniformity, cathode uniformity and dark current should result in greatly improved performance of existing guidance systems.

The techniques developed will provide a sound basis for the development of smaller devices with a reduced spread in performance characteristics. Reduction of associated electronic equipment complexity should then be possible.

Although substantial improvement in dark current performance was achieved in the tubes made during the program, it is concluded that a smaller image dissector with improved performance could be made if the number of dynodes is increased and their design changed. Doing this will allow the maximum advantage to be taken of the dynode secondary emission characteristics in the early dynodes where the signal level is low. This, and a reduction of the applied potentials between electrodes near the anode would result in a tube with better signal-to-noise and noise in signal-to-signal ratios.



THE IMAGE DISSECTOR TUBE

Figure 1

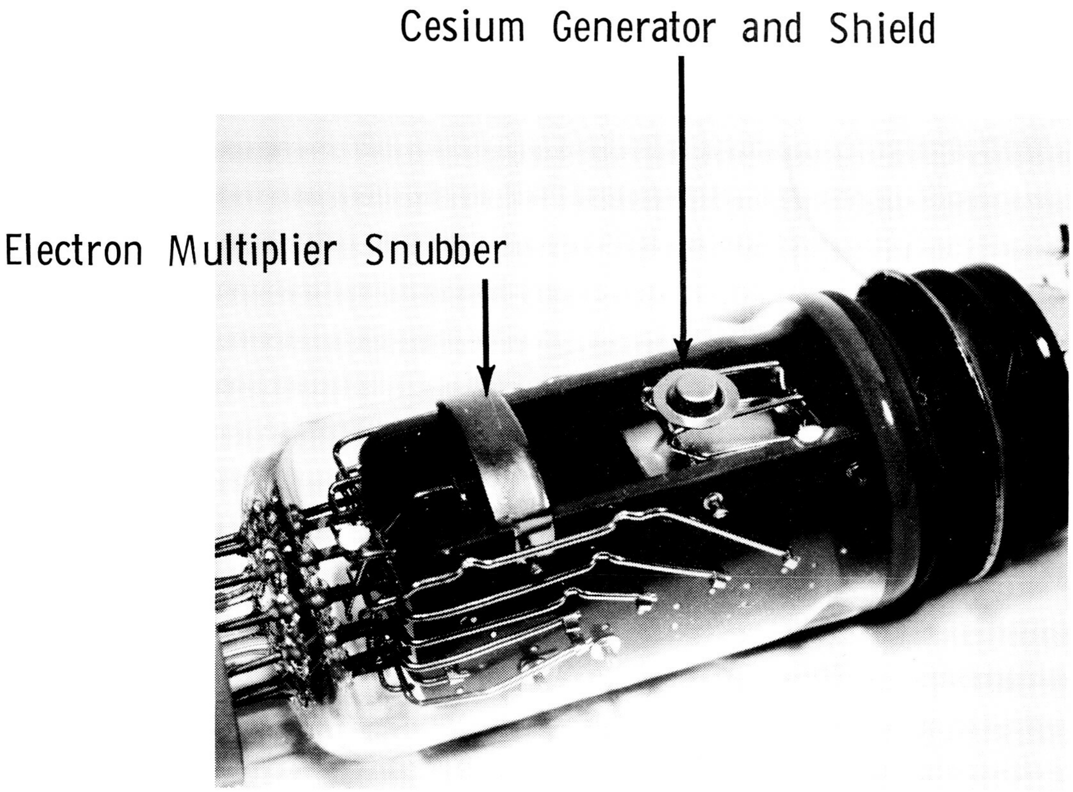
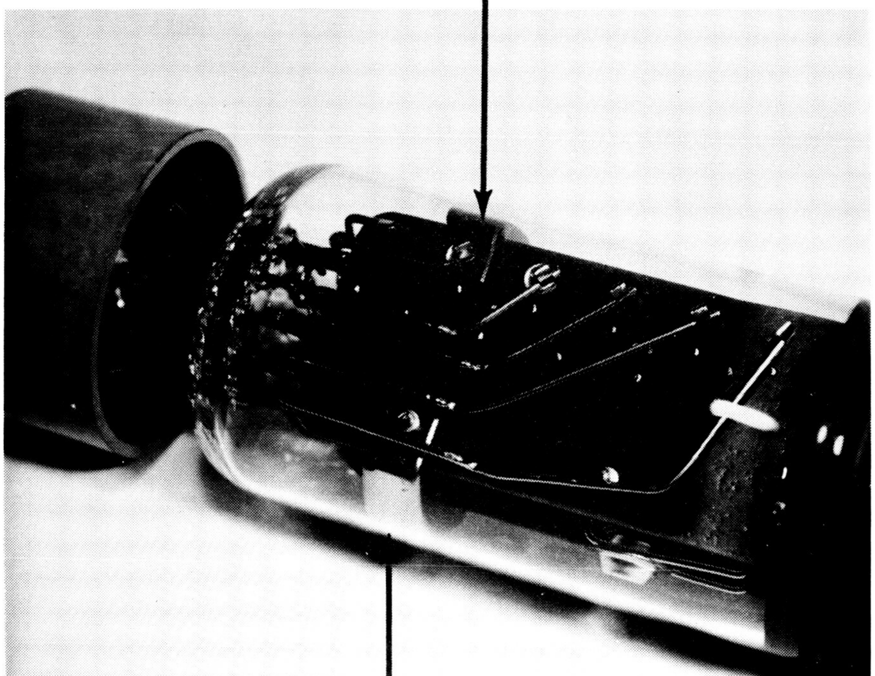


Figure 2

CL-1209A Image Dissector

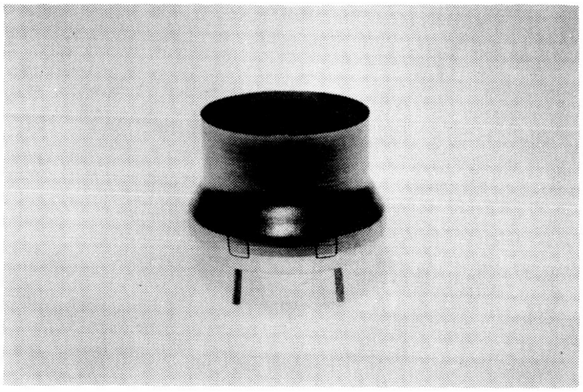
Electron Multiplier Snubber



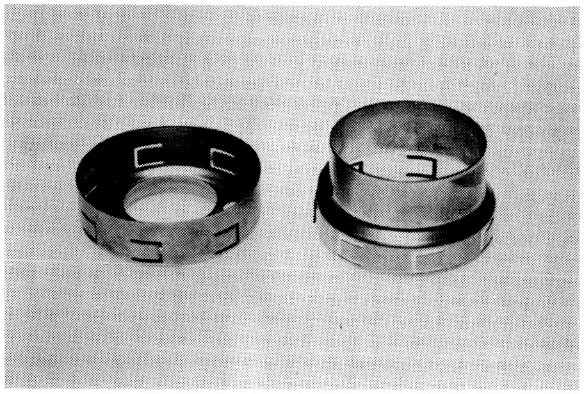
Electron Multiplier Snubber

Figure 3

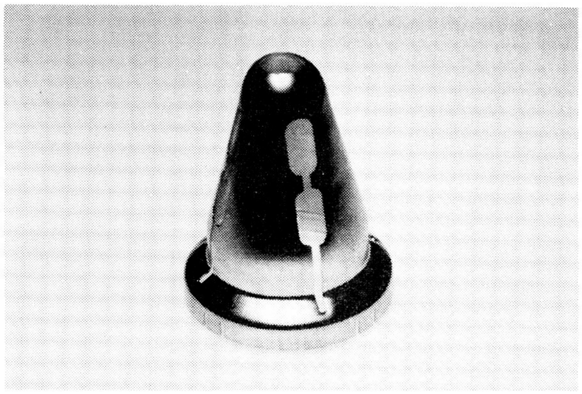
CL-1209A Image Dissector



(a) Original Focus Electrode



(b) Redesigned Two-Piece Focus Electrode

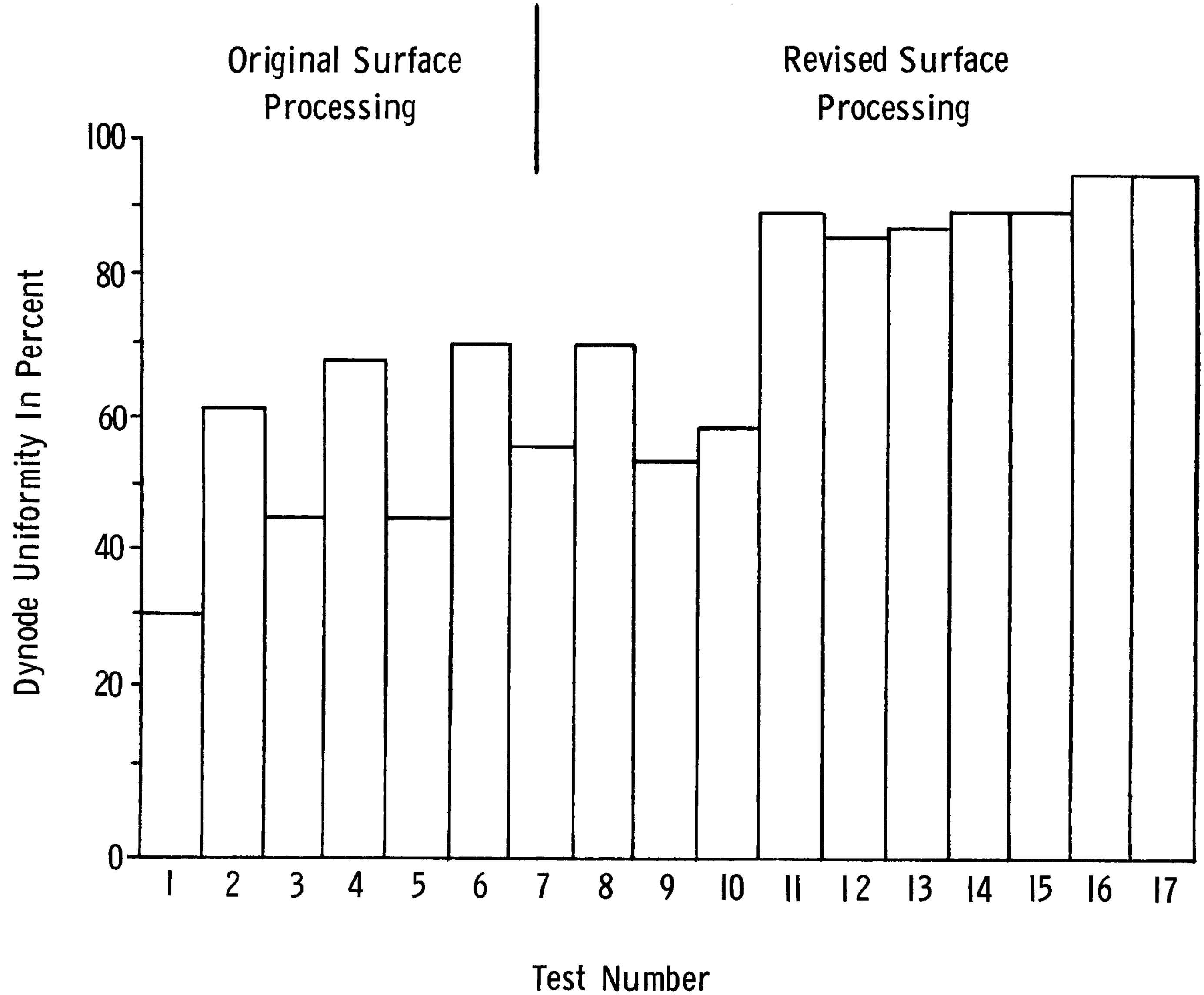


(c) Anode Cone

Figure 4

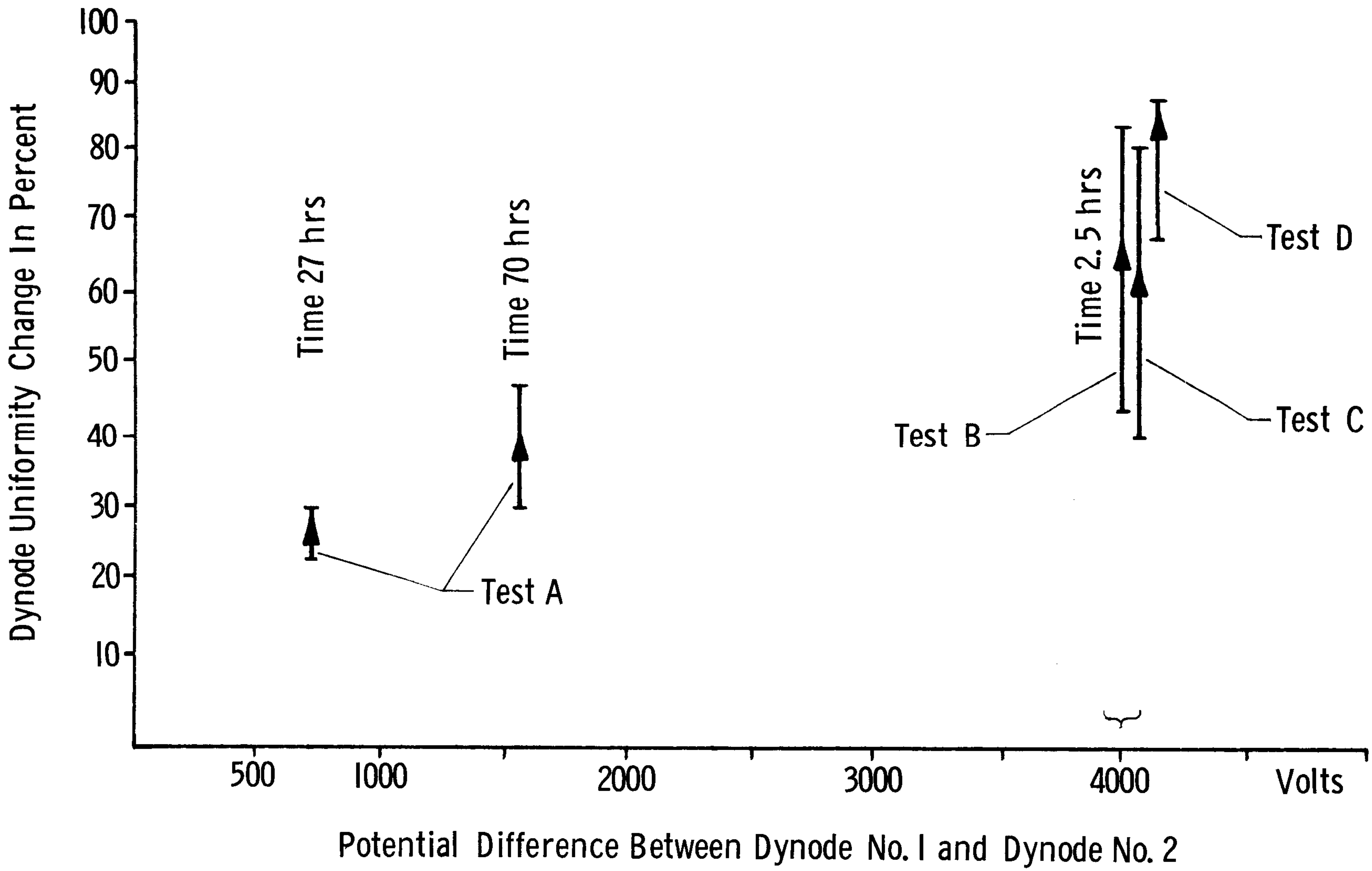
Figure 5

Deflection Cone System and Deflection Cone Assembly Jig



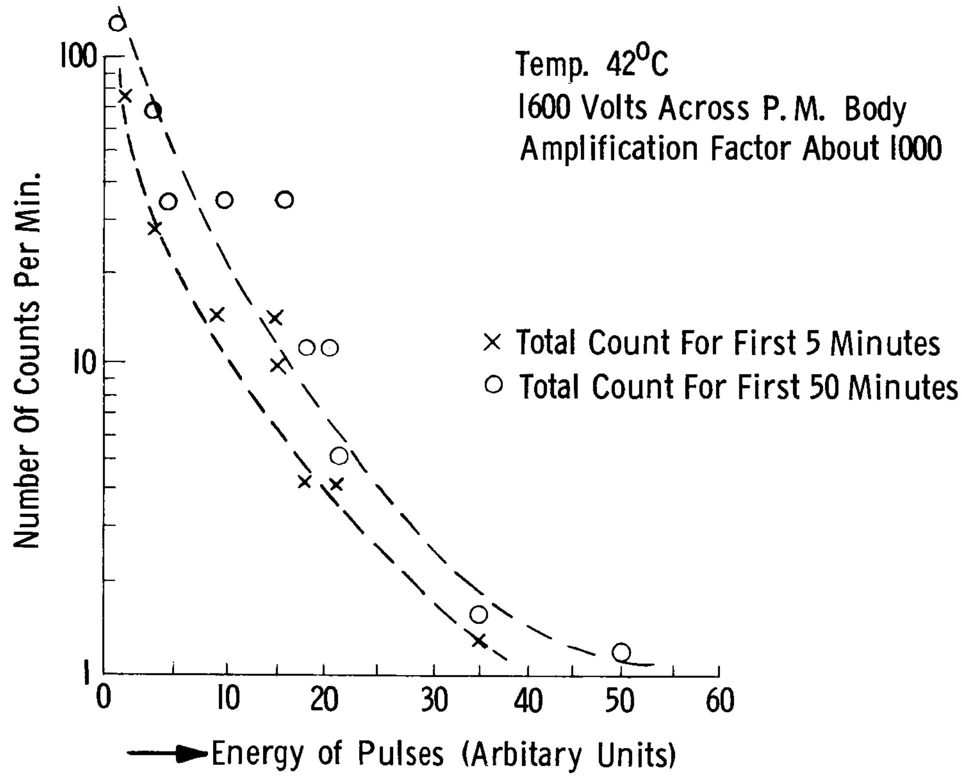
DISTRIBUTION OF DYNODE UNIFORMITY

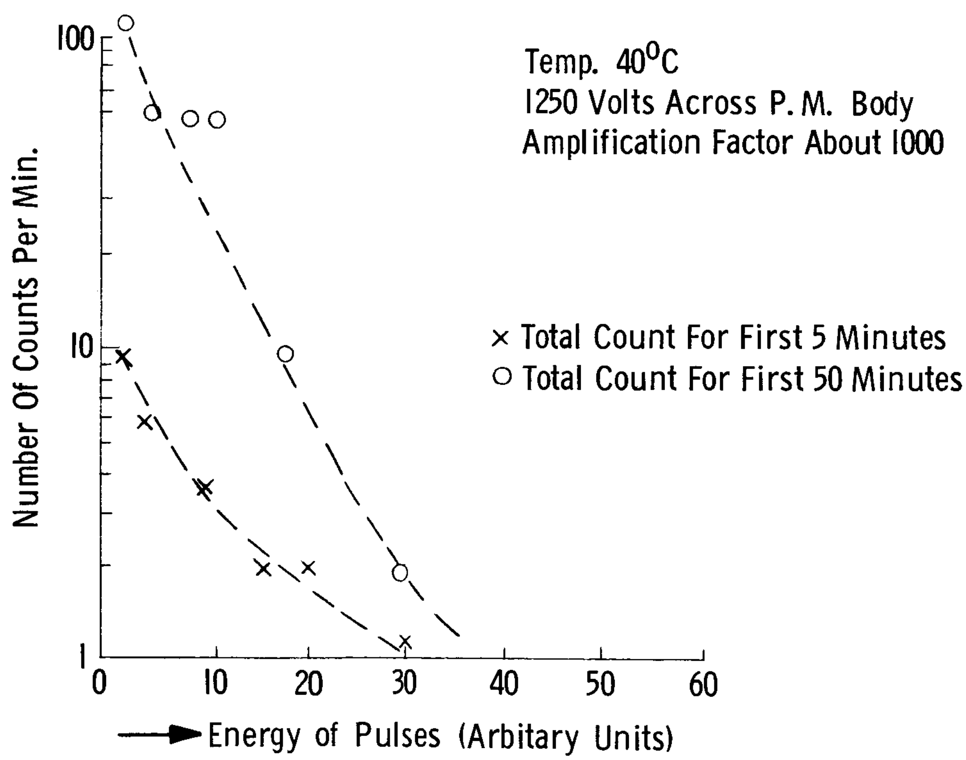
Figure 6



IMPROVEMENT IN APPLIED DYNODE UNIFORMITY
AS FUNCTION OF ELECTROSTATIC FIELD

Figure 7





SPURIOUS NOISE COUNT RATE vs ELECTRON MULTIPLIED APPLIED VOLTAGE

Figure 8

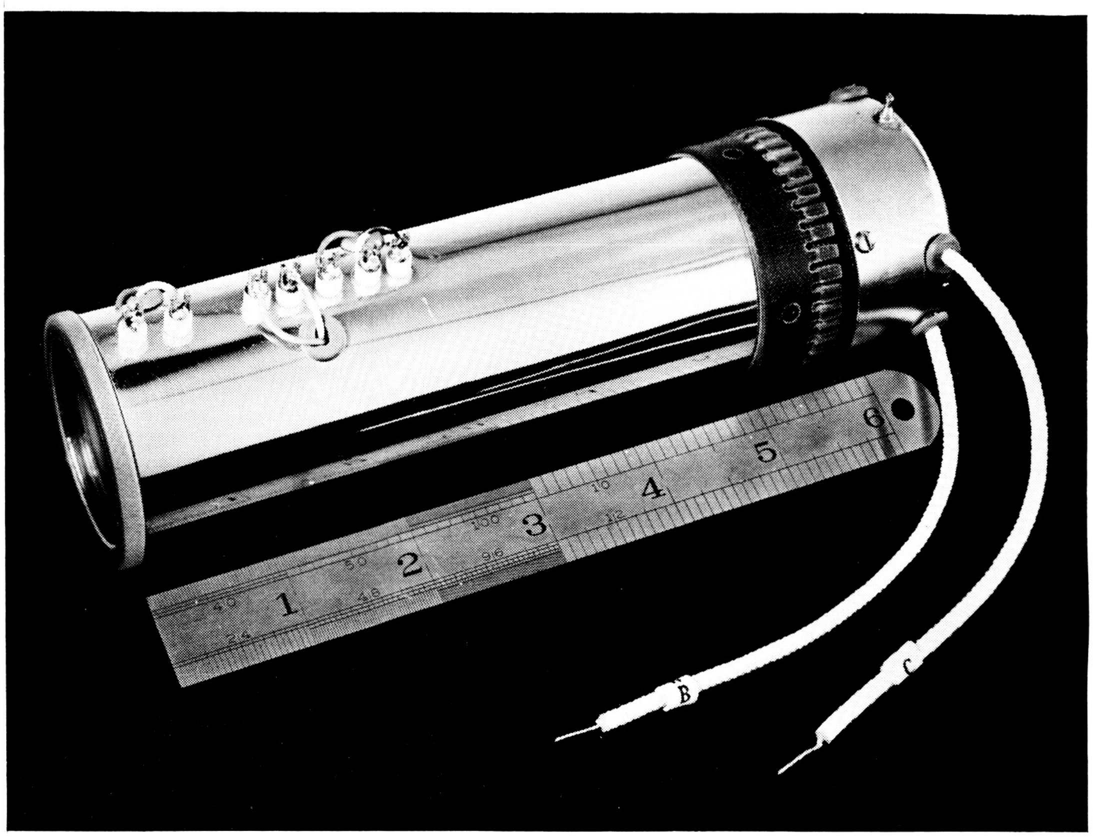


Fig. 9

Encapsulated Image Dissector

APPENDIX I

JPL SPECIFICATION NO. 31163 A

1. SCOPE

1.1 This specification covers the test requirements for an Electrostatic Image Dissector, to be utilized in the Attitude Control System for the Mariner C Spacecraft.

2. APPLICABLE DOCUMENTS

2.1 None

3. REQUIREMENTS

3.1 Conflicting Requirements - Any conflicting requirements arising between this specification and any other specification or drawing shall be referred in writing to the Jet Propulsion Laboratory (JPL) for interpretation and clarification.

3.1.1 Requests for Deviation - Any deviation from the requirements of this specification shall be considered a change or deviation and shall not be allowed except by written authorization from JPL.

3.2 Performance Characteristics

3.2.1 Reliability - The Image Dissector shall be capable of maximum reliability and continuous operation at one micro-ampere anode dc current output for a period of three years during which time performance shall be within limits established subsequently in this specification.

3.2.2 Spectral Response - The Image Dissector shall be furnished with an S-11 photocathode response.

3.2.3 Electron Aperture - The Image Dissector shall be furnished with a slit aperture 0.151 ± 0.005 inch long and 0.012 ± 0.002 inch wide with reference to the photocathode. The 0.151 inch axis of the slit shall be aligned with one axis of the deflection plates within 5°, and this set of deflection plates shall be referred to as the vertical deflection plates. This axis shall also be indicated by external marking on the tube photocathode. Orientation of the electron aperture with respect to the electron multiplier to minimize variation in output within the aperture as indicated in 4.1.5. (All dimensions in this specification are with reference to the photocathode).

3.2.4 Electro-Mechanical Null Accuracy - The geometric center of the electron aperture, as referenced to the photocathode, with zero volts on the deflection plates, shall be within 0.030 inches of the mechanical center of the photocathode, as defined by the outside diameter of the cathode window outside ring.

3.2.5 Electron Multiplier - A twelve stage electron multiplier shall be incorporated in the Image Dissector. The electron multiplier shall have a gain of not less than one million, when operated at 125 volts per stage and a photocathode-to-anode voltage of 700 volts. Focus voltages shall be adjusted for optimum resolution.

3.2.6 Photocathode Sensitivity - The photocathode sensitivity shall be greater than 34 microamperes per lumen as measured at the photocathode. The photocathode shall be masked to define a useful area of 0.160 ± 0.002 inches by 0.570 ± 0.002 inches. The 0.570 inch dimension shall be parallel to the long electron aperture axis within 5° and shall be centered to within 0.005 inch radius (0.010 total indicator reading) with respect to the outer surface of the cathode electrode. Measurements shall be made using a source color temperature of 2870°K. The photocathode shall first be coated with tin oxide to eliminate voltage gradients within the fiber optics. The mask shall be formed with vacuum deposited aluminum with maximum transmission of 0.001. The mask and tin oxide overcoat shall be electrically connected to the photocathode.

3.2.7 Response Uniformity - With a constant input of 10^{-8} lumens at 2870°K concentrated in a spot of 0.002 inch in diameter, no change in excess of 2:1 from the measured peak anode dc response shall be allowed when the spot is moved slowly across the useful area of the tube. This test shall be performed in accordance with 4.1.4 herin.

3.2.8 Focus - Focus shall be electrostatic. For all of the tests, focus voltage shall be held at one fixed voltage and shall not be "peaked" for focus vs. deflection. (All dimensions given herein are with reference to the photocathode).

3.2.9 Deflection - Internal symmetrical electrostatic deflection plates shall be provided which can deflect the focused electron image over a minimum of $\pm$ 0.25 inch from the mechanical axis of the tube. Deflection sensitivity shall be greater than 0.0016 inches per volts (plate to plate) at 700 volts of accelerating potential. Linearity of electron image deflection as a function of deflection potential (voltage with respect to the electron aperture anode) shall be 1.0 percent. Long term (3 year) repeatability of electron image deflection shall be no greater than 0.002 inch anywhere within the useful area defined in 3.2 herein.

3.2.10 Fatigue - Long term (3 year) stability of the Image Dissector shall be such that the luminous sensitivity of the tube shall not change by more than 2:1, when illuminated with 10^{-8} lumens concentrated in a fixed position spot 0.002 inch in diameter on the photocathode anywhere within the useful area of 3.2. This requirement is presently waived and is considered a design goal.

3.2.10.1 Burn-in Test - In order to age the Image Dissector tubes at approximately Canopus input levels, the following test shall be performed for 100 hours or more:

a. Flood the photocathode with approximately 0.02 ft-candle of 2870°K illumination.

b. Excite the tube with the following voltages:

(1) Photocathode to first dynode: 700 volts
(2) Last two dynodes: 125 volts per stage
(3) The remaining dynodes at such a voltage as to provide an output current of 0.1 microamp.

Once determined at the start of the test, all voltages shall remain constant throughout the test period. Every 25 hours the anode current shall be measured and recorded. After completion of the burn-in, the tube must pass all other requirements of this specification.

3.2.11 Sensitivity - The overall Image Dissector, with an excitation of 10^{-8} lumens at 2870°K concentrated in a spot 0.002 inch in diameter, shall evidence a minimum dc signal current output of not less than 0.4 microampere when operated at a dynode voltage of 125 volts/stage and a photocathode-to-anode voltage of 700 volts. (Dark current is subtracted to determine the signal current output). Focus voltage is that required for maximum resolution.

3.2.12 Resolution - Image focus shall be adequate to assure that signal pulse width shall not be greater than 0.010 inch in addition to the electron aperture width when the photocathode is illuminated at any point in the useful area with 10^{-8} lumens at 2870°K concentrated in a spot 0.002 inch in diameter. Pulse width shall be measured between points where the signal is down to 20 percent of the peak signal amplitude. (All dimensions are referenced to the photocathode).

3.3 Physical Characteristics

3.3.1 Dielectric Breakdown - The external electrical connections to the tube shall be designed to withstand a peak voltage of 3000 volts with no dielectric breakdown, either between connections or to support structure which may be grounded.

4. QUALITY ASSURANCE PROVISIONS

4.1 Functional Tests

4.1.1 Photocathode Sensitivity - The purpose of this test will be to evaluate the average sensitivity of the photocathode. The useful area of (3.2) the photocathode shall be fully illuminated with light at 2870°K. Illumination shall be 10 foot-candles. The cathode shall be operated at -30 volts and the focus electrode shall be operated at -27 volts with respect to the image aperture anode. The useful cathode current shall be measured as the difference between the cathode currents when the useful area of the cathode is illuminated and dark. The multiplier electrodes and the deflection plates shall be grounded. Useful cathode area is 6.35×10^{-4} $ft.^2$ for computation of photocathode sensitivity.

4.1.2 Photocathode Response Uniformity - With the Image Dissector set up as in the foregoing test (4.1.1), the photocathode shall be illuminated with a spot of light 0.1 inch in diameter. This spot shall be moved slowly down the length of the useful area of the cathode and the photocathode current measured at spot center increments of 0.050 inch from -0.200 to + 0.200 inches. There shall be no measurements less than 0.66 times the peak measured current. In each case the current measured shall be the difference between the current measured with the cathode illuminated and the cathode dark.

4.1.3 Multiplier Gain

a. Energize the Image Dissector with -700 volts photocathode and approximately -630 volts focus electrode (optimum focus) and ground all dynodes to the electron aperture. Illuminate the photocathode uniformity with approximately 10 ft-candles, at 2870°K and measure the resultant active photocathode current (subtract any dark current). (See Figure 1).

b. Insert an aperture 0.004 inches in diameter and a filter (or filters) of transmission one percent (flat with wave length over the S-11 region) directly in front of the fiber optic faceplate and in the geometric center (being careful not to damage the fiber optic surface).

c. Illuminate the combination of 4.1.3 b. with 10 foot-candles (2870°K) and energize the image section as in 4.1.3 a. and additionally energize the multiplier section to 125 volts per stage (1500 total). Record the resultant anode current. (Subtracting dark current).

d. Compute the multiplier gain by the following equations:

$$\text{Gain} = G = \frac{(I_4)\ (L_1)}{(I_1)\ (L_2)}$$

Where

L = Luminous input = ft/c x photocathode area ($ft.^2$)

L_1 = Luminous input of 4.1.3 a =

$$\frac{(0.160)\ (0.570)}{144}\ (10) = 6.35 \times 10^{-3} \text{ lumens}$$

L_2 = Luminous input of 4.1.3 b. = $\dfrac{T_3\ \pi(0.004)^2(10)}{4(144)}$

$= T_3\ 8.72 \times 10^{-7}$ lumens

I_4 = Anode Current of 4.1.3 d.

I_1 = Cathode Current of 4.1.3 a.

T_3 = Filter Transmission of 4.1.3 c.

R_c = Photocathode Response = $\dfrac{I_1}{L_1}$

The computed gain (G) shall not be less than 10^6.

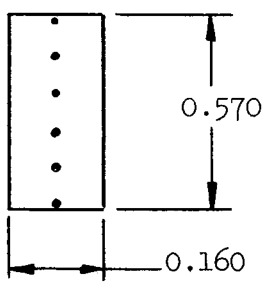
4.1.4 Response Uniformity - With the full image dissector energized, the illumination level set for 10^{-8} lumens concentrated in a spot 0.002 inches in diameter. The spot shall be slowly moved over the useful area of the photocathode. Measurements of peak dc anode signal output shall be taken at the following combinations of positions:

a. Horizontal axis 0.000 $\pm$0.045
b. Vertical axis 0.000 $\pm$0.050, $\pm$0.100, $\pm$0.150. $\pm$0.200, $\pm$0.245

For these measurements the deflection plates shall be driven from suitable deflection amplifiers and sweep shall not be employed on either axis (except as necessary in locating the aperture). The positioning head shall be adjusted to each of the indicated positions of the spot on the photocathode and the deflection voltages adjusted to center electron image on the slit. The output levels shall be plotted on suitable graphed paper. No measured active anode current level shall be less than 50 percent of the peak measured current. The minimum dc signal current shall be greater than 0.4 microamperes.

4.1.5 Dynode Uniformity - The purpose of this test is to determine the variation in anode output versus electron image location at the electron aperture. For a constant input of 10^{-8} lumens imaged on the front surface of the fiber optic window, the electron image may be moved by energizing the vertical deflection plates. When the electron image is moved in such a manner anywhere, ($\pm$0.060 inches) along the vertical center line of the electron aperture referred to photocathode, the resultant minimum anode dc output shall not be less than 80 percent of the peak value attainable.

4.1.6 Resolution - With the test conditions as defined in 4.1.5 a. sweep voltage of triangular waveform at 20 cps shall be applied to the horizontal deflection plates. The resulting signal waveform shall be observed on an oscilloscope. The pulse width between points at 20 percent of peak amplitude shall be measured at the center and at 0.050 inch increments along the center line of the long dimension of the slit. The focus voltage may be adjusted once on the axis of the tube at the start of the test to optimize the image focus. The measured pulse width shall not exceed 0.010 inch plus the width of the slit electron aperture (projected to the photocathode) at any of the 9 specific positions indicated below:



Active photocathode area nine points spaced in 0.050 inch increments from the center in either direction.

4.1.7 Leakage - The tube shall be energized as shown in Figure 2. Under these conditions there shall be no change in excess of two volts across any resistor when the tube is connected or disconnected from the bleeder (all connections). Measurements shall be made using an electrostatic voltmeter to avoid loading the circuitry. In addition, measured resistances between any one deflection plate and the remaining three, or to the image anode electrode shall not be less than 200 megohms when measured at 300 volts dc.

5. PREPARATION FOR DELIVERY - Not Applicable.

6. NOTES - Not Applicable.